

What is claimed is:

- 1 1. A method, using a computer, for performing defect analysis on a
2 plurality of images from an inspection system, comprising:
3 storing said plurality of images in a computer readable medium;
4 retrieving an inspection image from a first image of a stored plurality of
5 images;
6 retrieving a corresponding reference image from a second image of said
7 stored plurality of images; and
8 analyzing said inspection image and said corresponding reference image to
9 determine if a defect exists.
- 1 2. The method of claim 1 wherein said first image and said second
2 image are a same image.
- 1 3. The method of claim 1 wherein said stored plurality of images are
2 clipped images.
- 1 4. The method of claim 1 wherein said analyzing includes displaying
2 said inspection image.
- 1 5. The method of claim 1 wherein said analyzing occurs during actual
2 inspection.
- 1 6. The method of claim 1 wherein said analyzing occurs in after-
2 inspection follow-on analysis.
- 1 7. The method of claim 1 wherein said plurality of images are images
2 from die to die comparisons, array comparisons, or both.
- 1 8. A method, using a computer, for inspecting for defects in a circuit
2 pattern, comprising:
3 determining if there is a defect candidate image, by thresholding a
4 difference image, wherein said difference image comprises a difference between an
5 inspection image and a corresponding reference image;

6 if there is said defect candidate image, storing a clipped inspection image
7 in a computer readable medium, wherein said clipped inspection image is a portion of
8 said inspection image; and

9 if there is said defect candidate image, storing a corresponding clipped
10 reference image in said computer readable medium, wherein said corresponding clipped
11 reference image is a portion of said corresponding reference image.

1 9. The method of claim 8 further comprising storing a clipped defect
2 candidate image, when there is said defect candidate image.

1 10. The method of 8 further comprising, when there is said defect
2 candidate image, storing defect information, comprising defect candidate positional
3 coordinates, in said computer readable medium.

1 11. The method of 8 further comprising, when there is said defect
2 candidate image, determining a margin.

1 12. The method of claim 8 further comprising:
2 using said clipped inspection image and said clipped reference image to
3 determine a margin; and
4 storing said margin in said computer readable medium.

1 13. The method of claim 8 further comprising:
2 determining a classification, a threshold for a type of defect, or an
3 enhanced result based in part on said clipped inspection image and said clipped reference
4 image.

1 14. The method of claim 13 wherein said determining further uses
2 defect information.

1 15. An inspection system for examining a plurality of images showing
2 potential defects in a circuit pattern on a semiconductor material, comprising:
3 a defect image memory for storing clipped images of said plurality of
4 images;

5 an image analyzer, comprising a plurality of processors, coupled with said
6 defect image memory, for analyzing said clipped images retrieved from said defect image
7 memory; and

8 a non-volatile storage coupled with said image analyzer for storing said
9 clipped images and results of said analyzing.

1 16. The inspection system of claim 15 wherein said results are defect
2 detection margins.

1 17. The inspection system of claim 15 wherein non-volatile storage
2 further stores defect information.

1 18. The inspection system of claim 15 wherein said plurality of images
2 comprise an inspection image and a corresponding reference image.

1 19. A method for detecting defects in a circuit pattern on a
2 semiconductor material using an inspection system comprising:
3 storing a plurality of scanned images from a detecting apparatus;
4 determining an inspection image and a reference image from said plurality
5 of scanned images based on a selection of either die to die comparison or array
6 comparison; and

7 using said inspection image and said reference image, determining a defect
8 candidate image.

1 20. The method of claim 19 further comprising:
2 when then there is said defect candidate image, clipping a first area from
3 said inspection image and a corresponding second area from said reference image.

1 21. The method of claim 20 further comprising:
2 sending a first clipped image, comprising said first area, for storage in a
3 defect image memory.

1 22. The method of claim 19 wherein said selection is different for
2 different areas of a wafer.

1 23. An image processing system for detecting defects in a circuit
2 pattern on a semiconductor material using images from a detecting apparatus, said image
3 processing system comprising:

4 an image memory for storing said images; and
5 a defect detection image processing module for detecting defect candidate
6 information from stored images, wherein at least one of said stored images includes an
7 inspection image.

1 24 The image processing system of claim 23 wherein said at least one
2 of said stored images further includes a related reference image.

1 25 The image processing system of claim 23 wherein said defect
2 candidate information, comprising defect candidate positional information, is used by said
3 defect detection image processing module to clip said inspection image and said related
4 reference image.

1 26. The image processing system of claim 23 further comprising an
2 overall control for determining when die to die comparison or array comparison is used
3 on said inspection image and said related reference image.

1 27. A method using a computer for determining an updated threshold
2 for use in actual inspection of a semiconductor wafer, said method comprising:
3 setting an initial threshold;
4 determining a plurality of difference metrics using said initial threshold;
5 determining a difference distribution based on said plurality of difference
6 metrics; and
7 determining said updated threshold based on an evaluation of said
8 difference distribution.

1 28. The method of claim 27 wherein a difference metric of said
2 plurality of difference metrics comprises thresholding a difference between a clipped
3 inspection image and a clipped reference image.

1 29. The method of claim 27 wherein a difference metric of said
2 plurality of difference metrics comprises a margin.

1 30. The method of claim 27 wherein a difference metric of said
2 plurality of difference metrics comprises a signal amplitude difference between a
3 maximum signal value of a cross-section of a difference image and said initial threshold,
4 said difference image comprising subtracting a clipped reference image from a clipped
5 inspection image.

1 31. The method of claim 27 wherein said evaluation of said difference
2 distribution comprises, finding a minimum in the difference distribution.

1 32. The method of claim 27 wherein said evaluation of said difference
2 distribution comprises finding a stabilized area under said difference distribution.

1 33. The method of claim 27 wherein said evaluation of said difference
2 distribution comprises using a fixed value for a defect count or defect density.

1 34. A method of resetting a threshold using a display coupled with a
2 computer, said method comprising:
3 displaying a first threshold value on said display, said first threshold value
4 used to select defect candidate image indications to be shown on a defect candidate
5 distribution screen of said display;
6 changing said first threshold value to a second threshold value, wherein
7 said defect candidate image indications on said defect distribution screen change
8 responsive to said second threshold value.

1 35 The method of claim 34 further comprising:
2 selecting a selected indication of said defect candidate image indications;
3 and viewing an inspection image associated with said selected indication.

1 36 The method of claim 34 wherein said first threshold is calculated
2 using an electron beam noise value for a SEM system.

1 37. A method in a computer system for determining a threshold for use
2 in actual inspection of a semi-conductor material, comprising a circuit pattern, said
3 method comprising:
4 displaying a first threshold and a second threshold;

5 displaying a graphic representation of a defect candidate image with a
6 margin greater than or equal to said second threshold minus said first threshold;
7 when said graphic representation of said defect candidate image is selected
8 for expanded viewing, displaying a clipped image associated with said graphic
9 representation; and
10 when said defect candidate image is a false defect, and a predetermined
11 number of allowable false defects is exceeded, receiving a new second threshold.

1 38. The method of claim 37 wherein said clipped image is selected
2 from a group consisting of a clipped inspection image, a clipped reference image, or a
3 clipped defect candidate image.

1 39. A method in a computer system for displaying a defect candidate,
2 said defect candidate stored in a memory, said method comprising:
3 displaying a two-dimensional defect candidate distribution for a threshold
4 on a first screen, said two-dimensional defect candidate distribution comprising an
5 indication of said defect candidate; and
6 displaying on a second screen an expanded view of said defect candidate,
7 responsive to a selection of said indication on said first screen.

1 40. The method of claim 39 wherein said expanded view comprises an
2 image associated with said defect candidate and selected from a group consisting of a
3 clipped inspection image, a clipped reference image, or a defect candidate image.

1 41. The method of claim 39 wherein said expanded view comprises a
2 re-scanned image of said defect candidate.

1 42. The method of claim 39 further comprising a threshold screen for
2 changing said threshold.

1 43. The method of claim 39 further comprising a screen displaying a
2 graph of defect density versus threshold.

1 44. The method of claim 39 wherein said two-dimensional defect
2 candidate distribution displays defect candidates responsive to a user selected area.

1 45. The method of claim 39 wherein said two-dimensional defect
2 candidate distribution displays defect candidates by type of defect.

1 46. The method of claim 45 wherein each type of defect has a different
2 symbol, said defect being displayed using a symbol.

1 47. The method of claim 45 wherein each type of defect has an
2 associated threshold value.

1 48. The method of claim 39 wherein said two-dimensional defect
2 candidate distribution displays defect candidates as symbols.

1 49. The method of claim 48 wherein a symbol of said symbols
2 comprise a grayscale value.

1 50. The method of claim 49 wherein said grayscale value is related to a
2 margin.

1 51. The method of claim 49 wherein said grayscale value is related to
2 an enhanced result.

1 52. The method of claim 48 wherein a symbol of said symbols
2 comprise a color value.

1 53. The method of claim 48 wherein a symbol of said symbols
2 comprise a black or a white value.

1 54. A system for displaying a symbol associated with a defect
2 candidate of said plurality of defect candidates, comprising:

3 a computer readable medium for storing images associated with said
4 plurality of defect candidates, wherein said images comprise an inspection image and a
5 reference image associated with said defect candidate;

6 a processor coupled with said computer readable medium for determining
7 a margin associated with said defect candidate, said margin calculated using said
8 inspection image and said reference image; and

9 a display for displaying said symbol when said margin is equal to or above
10 a threshold difference.

1 55. The system of claim 54 wherein said threshold difference is a
2 difference between a display threshold value and a predetermined initial threshold value.

1 56. A distributed system for inspecting semiconductor circuit pattern
2 defects, comprising:
3 an inspection apparatus for acquiring a plurality of images associated with
4 said semiconductor circuit pattern defects and for performing defect analysis on a
5 plurality of stored images;
6 a server connected to said inspection apparatus via a communications
7 network for storing said plurality of images, and for providing access to said plurality of
8 stored images; and
9 a client computer connected to said server and said inspection apparatus
10 via said communications network for displaying a plurality of symbols associated with
11 selected images of said plurality of stored images in response to selection of said selected
12 images by said defect analysis.

1 57. The distributed system of claim 56 wherein said communications
2 network comprises an Internet.

1 58. The distributed system of claim 56 wherein said communications
2 network comprises a Local Area Network.

1 59. The distributed system of claim 56 wherein said client computer
2 further displays an image of said selected images in response to a user selection of an
3 associated symbol of said plurality of symbols.

1 60. The distributed system of claim 56 wherein said defect analysis
2 comprises calculation of a margin.

1 61. The distributed system of claim 56 wherein said defect analysis
2 comprises threshold recalculation.

1 62. A distributed system for inspecting semiconductor circuit pattern
2 defects, comprising:
3 an inspection apparatus for acquiring a plurality of images associated with
4 said semiconductor circuit pattern;
5 a server coupled with said inspection apparatus via a communications
6 network, said server operably disposed for:
7 storing said plurality of images;
8 performing defect analysis on a plurality of stored images; and
9 providing access to said plurality of stored images; and
10 a client computer coupled with said server via said
11 communications network for displaying a plurality of symbols associated with
12 selected images of said plurality of stored images in response to selection of said
13 selected images by said defect analysis.

1 63. A method for determining an inspection threshold used in actual
2 defect inspection of a semiconductor, said method comprising:
3 calculating a first threshold using a defect difference distribution;
4 storing a second threshold based on said first threshold in a computer
5 readable medium; and
6 using said second threshold in actual defect inspection.

1 64. The method claim 63 wherein said computer readable medium
2 includes a recipe comprising said second threshold.

1 65. The method claim 63 wherein said first threshold is greater than a
2 predetermined initial threshold.

1 66. A method for determining a selected threshold of a plurality of
2 thresholds, said plurality of thresholds for use in actual defect inspection of a
3 semiconductor, said method comprising:
4 determining said plurality of thresholds from a defect difference
5 distribution;
6 displaying to a user an indication for each of said plurality of thresholds;
7 and

8 responsive to said user selection of a selected threshold of said plurality of
9 thresholds, displaying symbols of defects with differences greater than or equal to
10 said selected threshold.

1 67. The method of claim 66 wherein said determining said plurality of
2 thresholds is based on one or more local minimums in said defect difference distribution.

1 68. A system for determining a first threshold for use in actual
2 inspection of circuit pattern defects in a semiconductor material, said system comprising:
3 a defect detection unit for determining defects with differences above a
4 second threshold minus a predetermined value; and
5 a display having an input mechanism for adjusting said first threshold,
6 wherein said first threshold has an initial value of said second threshold.

1 69. The method of claim 68 wherein said second threshold is related to
2 a defect difference distribution.

1 70. An image processing system for determining a new threshold for
2 use in inspection of a circuit pattern on a semiconductor material, comprising:
3 a defect detection unit for determining a plurality of defect sets, wherein a
4 defect set of said plurality of defect sets comprises an inspection image and a reference
5 image with a difference above a predetermined threshold ; and
6 an image analysis unit for using said plurality of defect sets to determine a
7 difference distribution and for using said difference distribution to determine said new
8 threshold.

1 71. The image processing system of claim 70 wherein at least one
2 image in said defect set is a clipped image.

1 72. The image processing system of claim 70 further comprising a
2 defect image memory for storing said defect set.

1 73. The image processing system of claim 70 further comprising an
2 image memory comprising said reference image and said inspection image.

1 74. The image processing system of claim 70 further comprising a
2 storage medium for storing said defect set.

1 75. A method for inspecting a specimen, comprising:

2 setting a threshold value;
3 detecting a detected image of a specimen;
4 comparing the detected image to a reference image;
5 extracting from the comparing, a defect candidate using the threshold
6 value;
7 storing an information of the defect candidate to a memory;
8 setting a new threshold value; and
9 extracting a defect from the defect candidate using the stored information
10 and the new threshold value .

1 76. A method of inspecting a specimen according to claim 75, wherein
2 the information of the defect candidate stored in the memory includes at least one of the
3 following: a defect candidate position, a defect candidate area, a defect candidate x and y
4 projection size, a maximum difference between the detected image and the reference
5 image, a defect texture, or a reference texture.

1 77. A method of inspecting a specimen according to claim 75, wherein
2 the information of the defect candidate stored in the memory includes an image of the
3 defect candidate.

1 78. The method of claim 75 wherein the specimen includes a circuit
2 pattern on a semiconductor wafer.

1 79. A method for inspecting a circuit pattern on a semiconductor
2 material comprising:
3 setting an initial threshold;
4 detecting an inspection image;
5 determining defect candidate information by thresholding a comparison
6 between said inspection image and a reference image, wherein said thresholding uses said
7 initial threshold;
8 determining a new threshold using said defect candidate information; and
9 evaluating a defect in said inspection image using said new threshold.

1 80. The method of claim 79 wherein said defect candidate information
2 includes a margin.

1 81. A computer program product stored on a computer readable
2 medium for inspecting a specimen, comprising:
3 code for setting a threshold value;
4 code for detecting a detected image of a specimen;
5 code for comparing the detected image to a reference image;
6 code for extracting from the comparing, a defect candidate using the
7 threshold value;
8 code for storing an information of the defect candidate to a memory;
9 code for setting a new threshold value; and
10 code for extracting a defect from the defect candidate using the stored
11 information and the new threshold value.

1 82. A computer program product stored on a computer readable
2 medium for inspecting a circuit pattern on a semiconductor material comprising:
3 code for setting an initial threshold;
4 code for detecting an inspection image;
5 code for determining defect candidate information by thresholding a
6 comparison between said inspection image and a reference image, wherein said
7 thresholding uses said initial threshold;
8 code for determining a new threshold using said defect candidate
9 information; and
10 code for evaluating a defect in said inspection image using said new
11 threshold.

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